

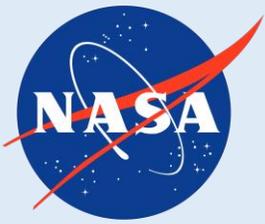
SHADOZ (Southern Hemisphere Additional Ozonesondes) Project Update: 2020 Archive and the ASOPOS Activity

Debra Kollonige^{1,2}, Anne Thompson² & Ryan Stauffer^{2,3}

1- SSAI (Science Systems & Applications Inc), 2- NASA/GSFC, & 3- ESSIC, UMCP

NOAA eGMAC Remote Session

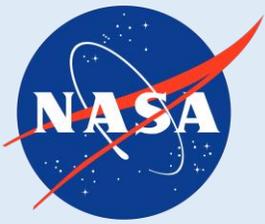
17 July 2020



Road Map



- Global Ozone sonde Network: Where are SHADOZ stations?
- SHADOZ History & Archive
 - SHADOZ Milestones: 14 stations, > 20 sponsoring organizations
 - Contributions to Satellite Validation
 - Data Archive & Status in 2020
 - Other 2020 Archive Updates (DOI, Metadata, & more)
- SHADOZ Recent Publications
 - Publications: Stauffer et al. (2020) & Thompson et al. – Upcoming!
 - Newsletter 29
- Data Quality Assurance
 - ASOPOS Activity
 - Global Ozone sonde Station Survey

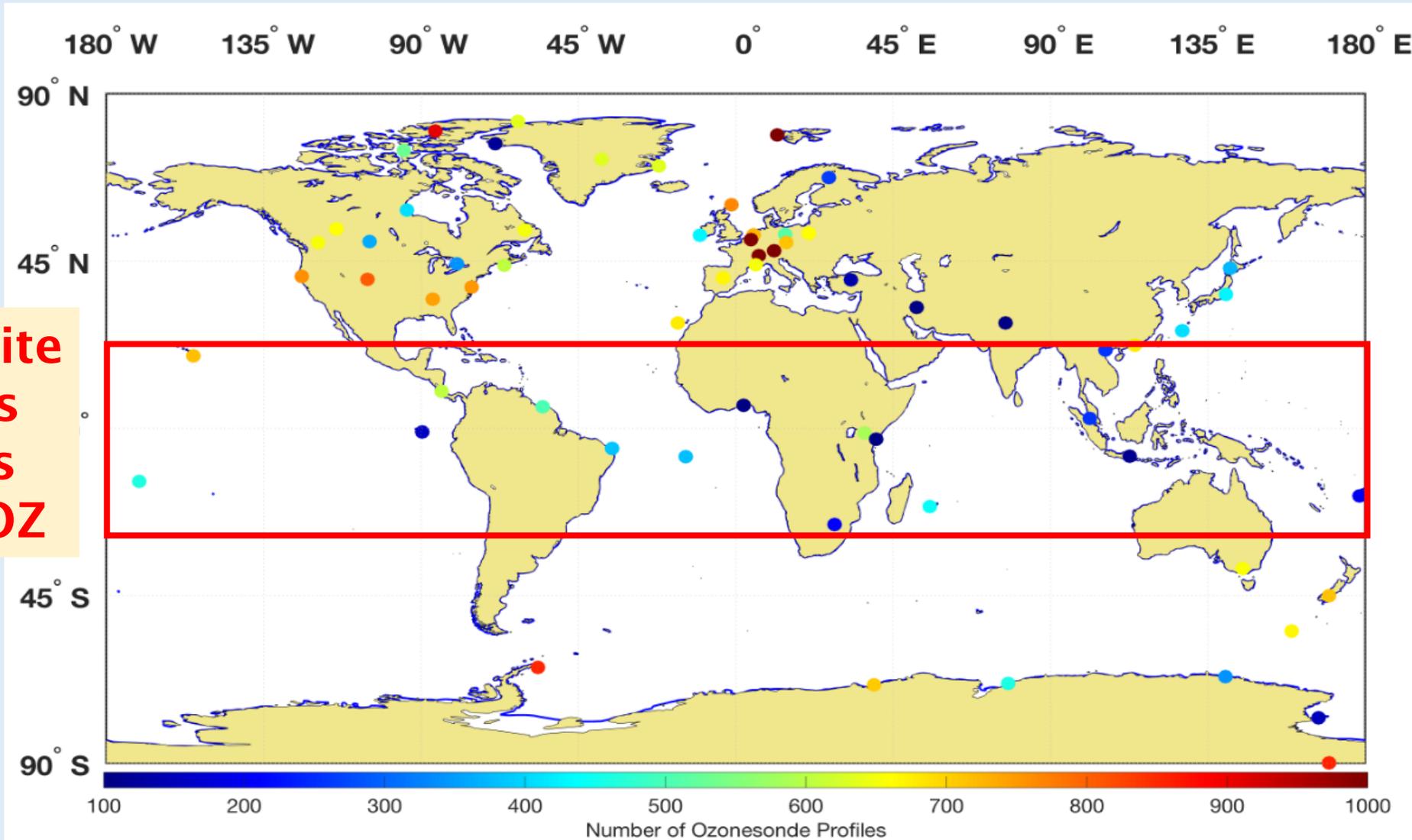


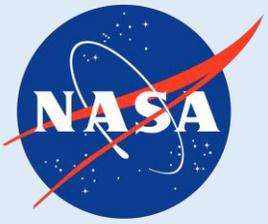
Global Ozonesonde Network

Until 1998, only ~200-300 tropical ozonesonde profiles were available for analysis from campaigns like SAFARI-92.



Every site in this box is SHADOZ

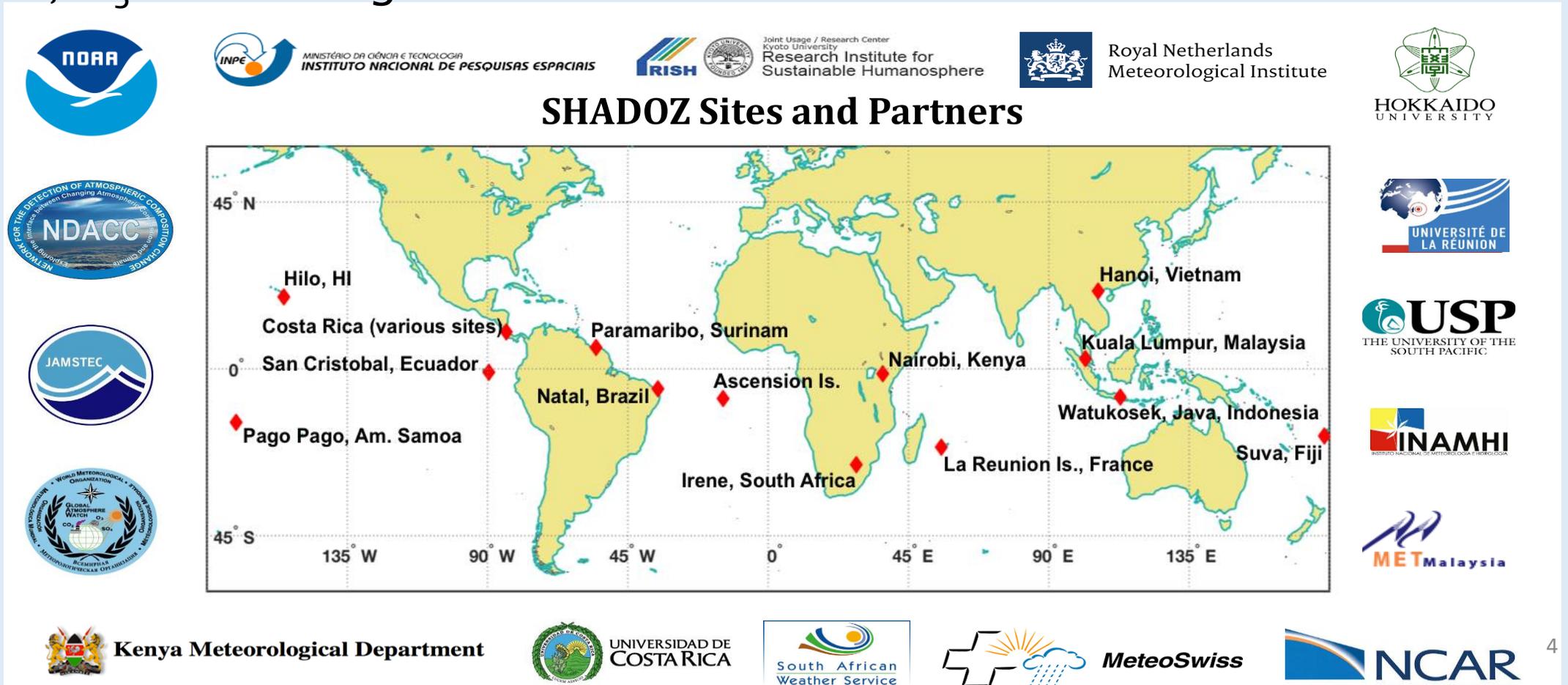


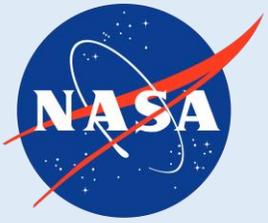


SHADOZ Milestones: Goal for Network



- Organized existing sites to regularly launch starting in 1998.
- Producer and provider of tropical & sub-tropical ozone data to support: process studies, O₃ monitoring & trends for assessments.

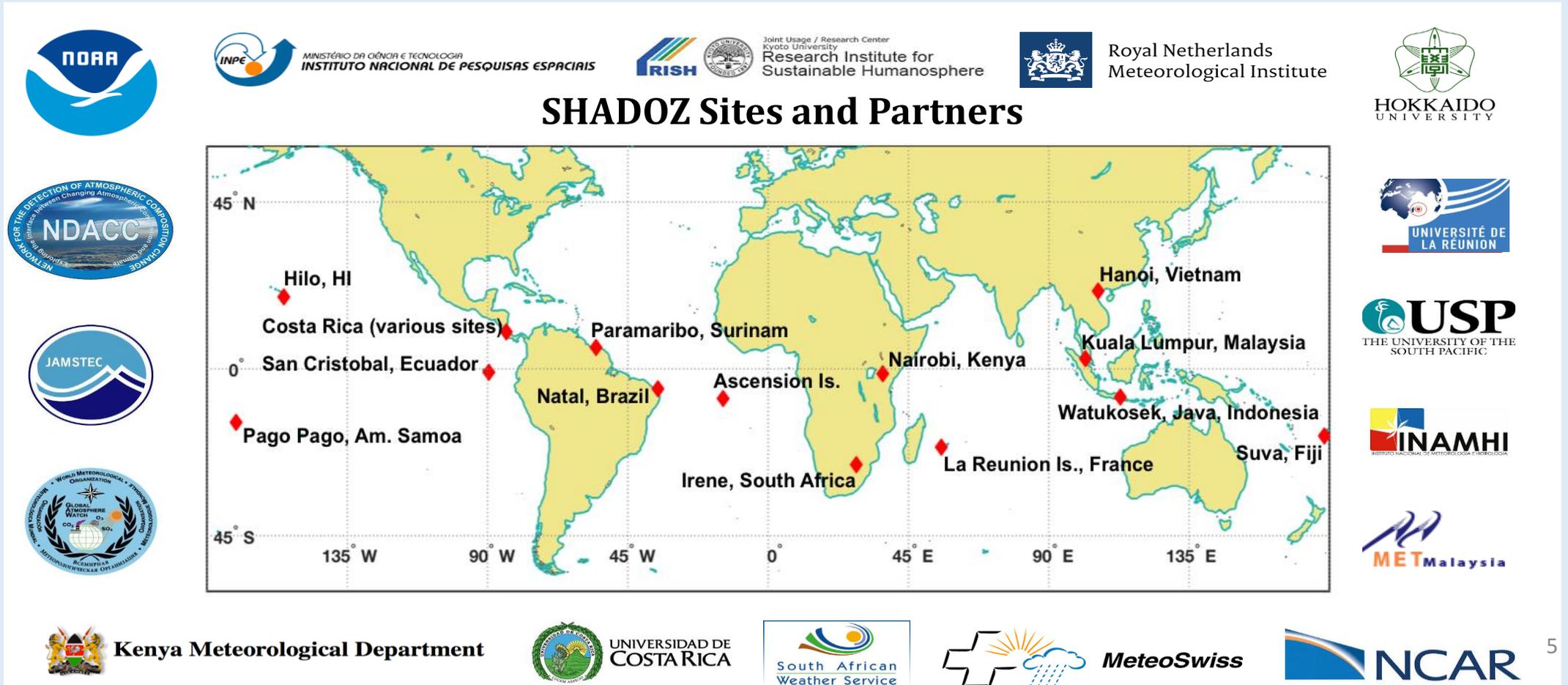


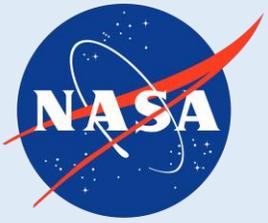


SHADOZ Milestones: Stations with 10+ Year Records



- 1998: 1 stable, 8 intermittent stations
- 2009: NDACC & WMO/GAW affiliations
- NOW: 14 sites with 10-yr record
- 2020: 8700+ O₃, PTU profile sets

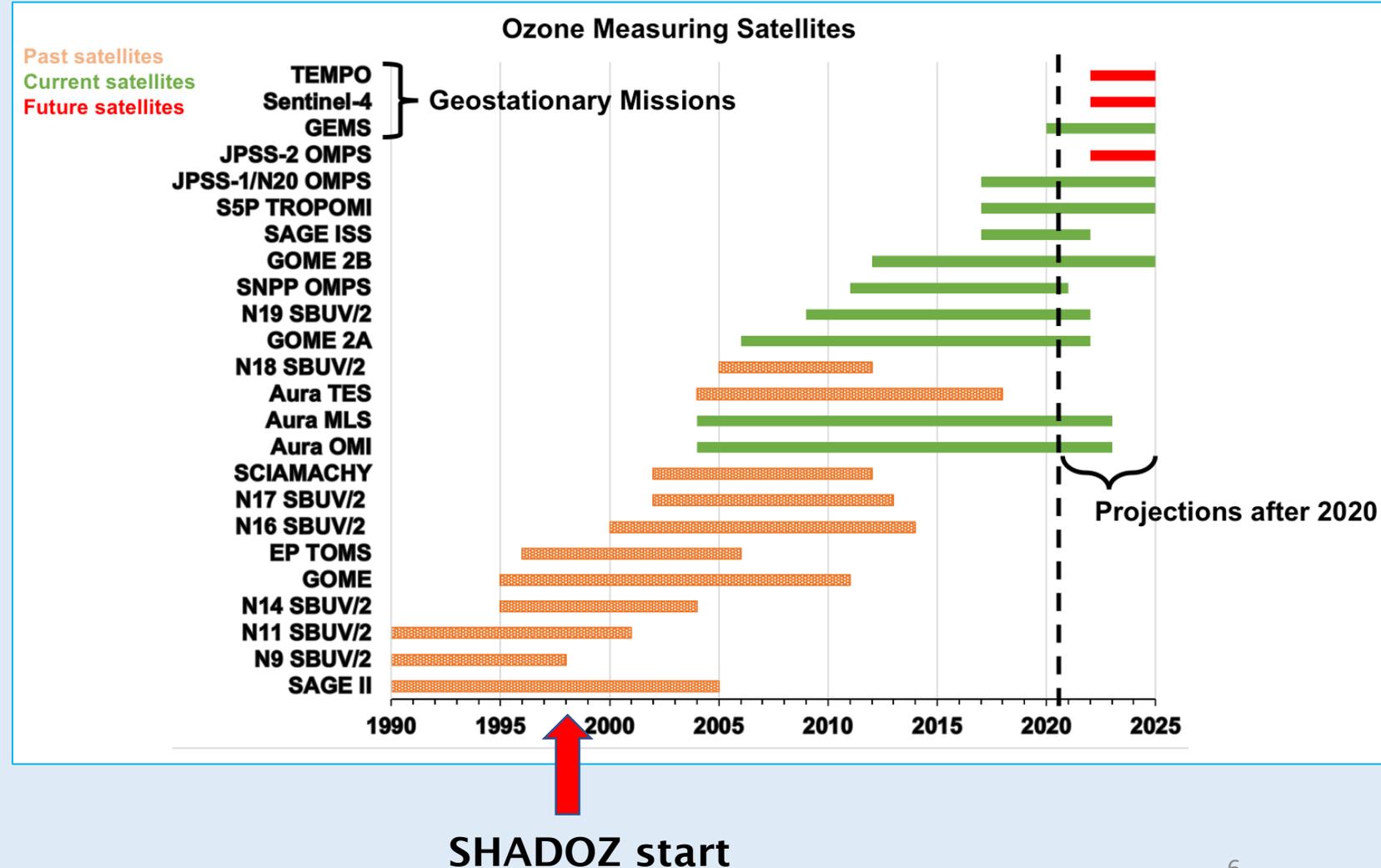


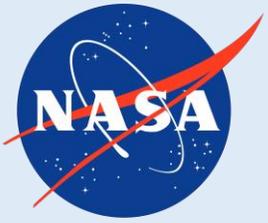


SHADOZ Contributions to Satellite Validation



- SHADOZ has supported many O₃ measuring satellites since its start.
- Tropical ozonesondes help refine satellite algorithms to retrieve specialized data products (eg. tropospheric and total column O₃)
- Supported recent IGAC Trop. Ozone Assessment Report (TOAR), SPARC/LOTUS, & 2018 Ozone Assessment.
- Supporting host of European initiatives in Copernicus framework.

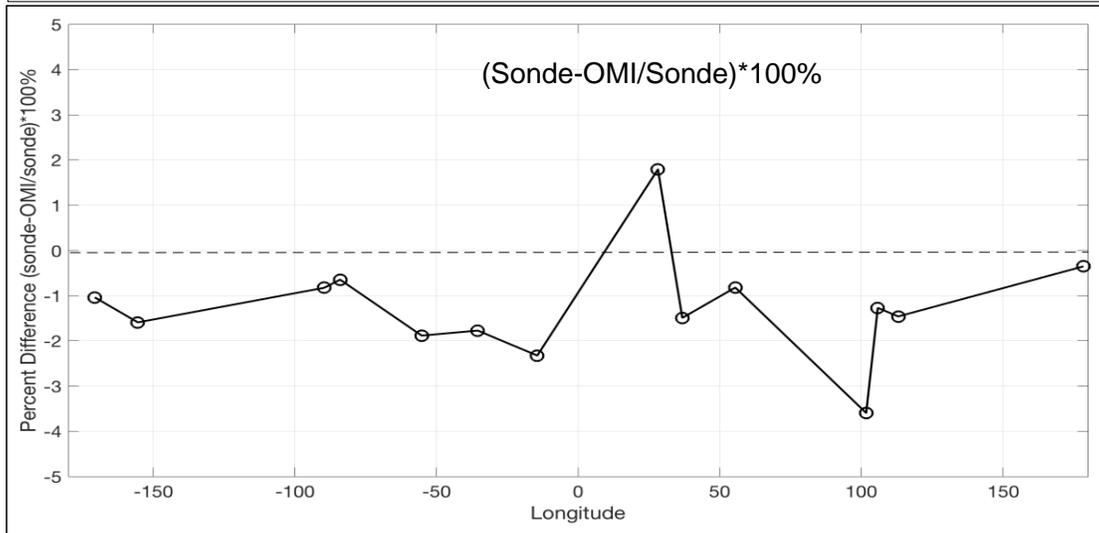
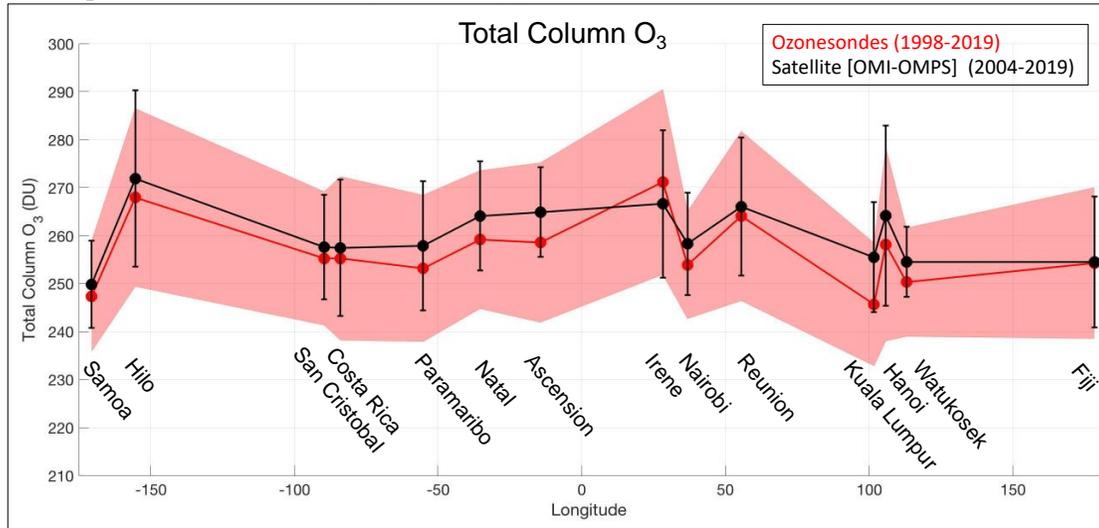




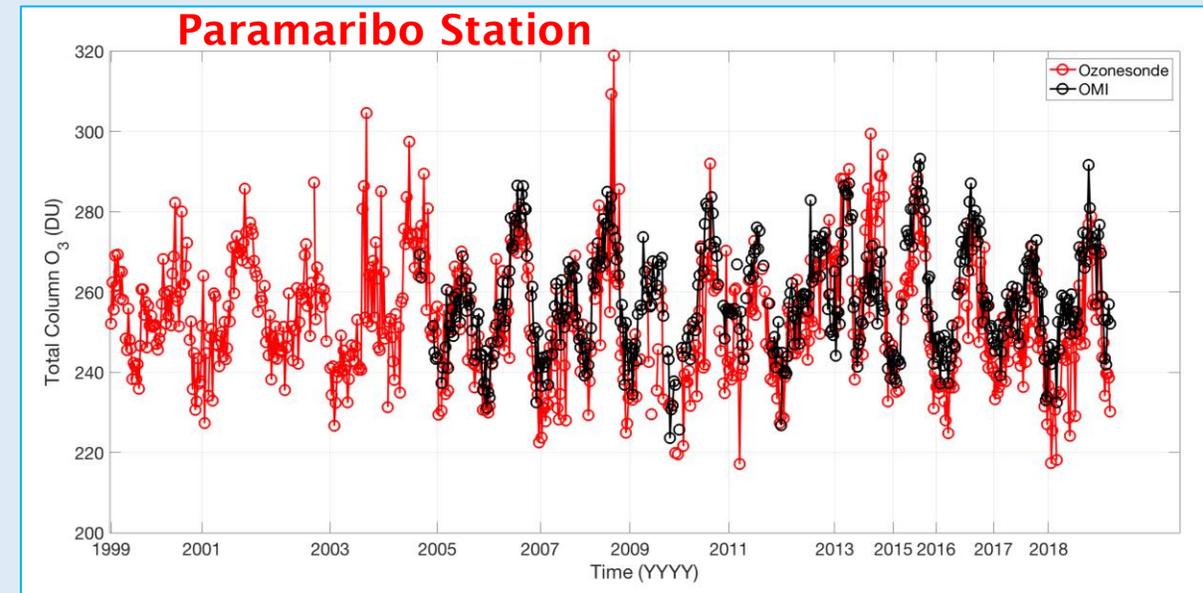
SHADOZ Contributions to Satellite Validation



Thompson et al. (2019), NASA Earth Observer

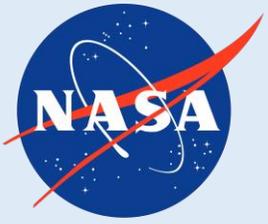


- SHADOZ stations agree within 4% of Aura Ozone Monitoring Instrument (OMI) for 2004-2019 period.
- Most are 2% or less – see Paramaribo below.
- Ozonesondes are the truth!



Kollonige et al., 2020 AMS Meeting

Where can I find SHADOZ data & what is its status in 2020?



Data Archive & Status in 2020

<https://tropo.gsfc.nasa.gov/shadoz>



- Research archive, not operational. Stations send data: weekly -> 2-3 times/yr.
- 2019 data drop due to cutbacks & supply shortages at some stations.
- During global 2020 COVID-19 shutdowns: several stations maintained launch schedules in some capacity where possible.

NASA National Aeronautics and Space Administration
Goddard Space Flight Center

SHADOZ -- Southern Hemisphere Additional Ozoneondes
An Archive of sub/tropical and remote ozoneonde data

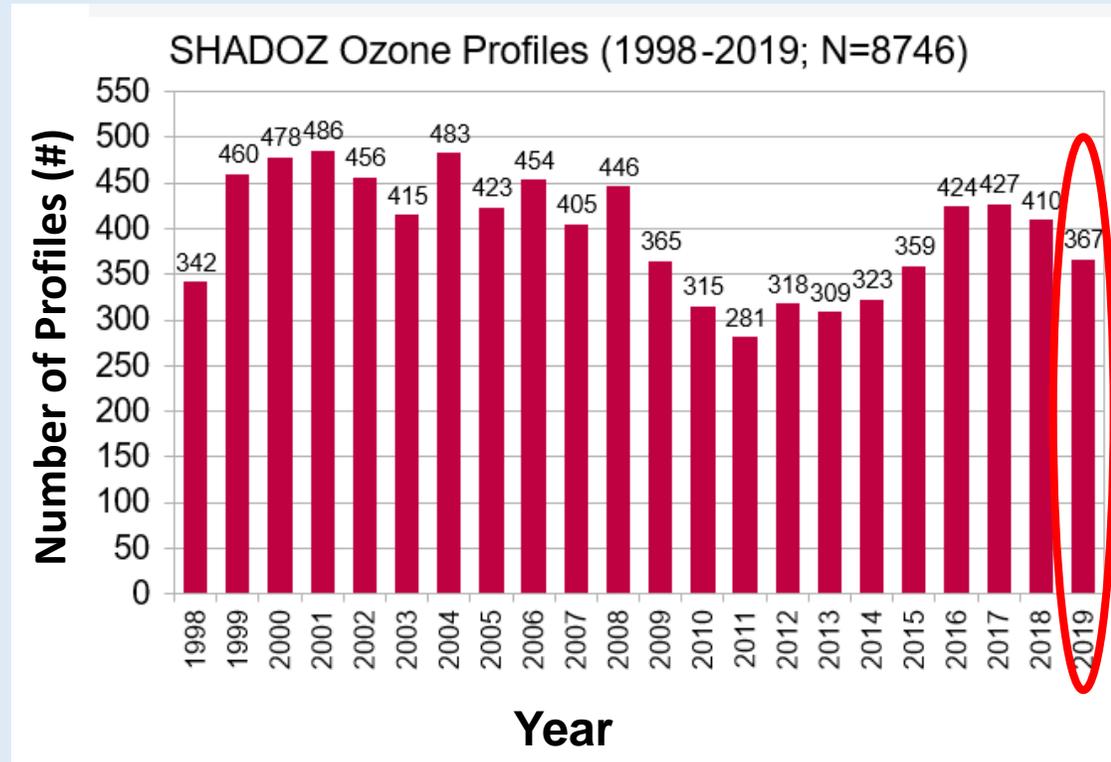
HOME | PI CONTACTS | **DATA ARCHIVE** | NEWSLETTER | PAPERS | LINKS

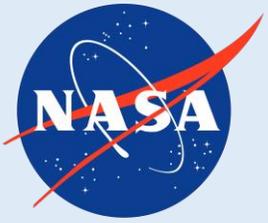
Attention!! Ozoneonde Data Cave!!

- 8 SHADOZ stations exhibit a 2-6% "drop" in total column ozone (TCO) beginning 2014-2016, depending on the station.
- The ozoneonde community first documented this in Thompson et al. (2017; Figure 4) and Sterling et al. (2018; Figure 14). Click PAPERS link in banner for links to references.
- Analysis and tests by the ozoneonde community are ongoing and will be documented in a publication. Stay tuned for updates.
- Examples of satellite comparisons with an "Affected" station and "Unaffected" station (Tables below) are illustrated [HERE](#). Comparisons with ground-based column instruments (Dobson, Brewer, SAOZ) are similar.
- STATUS SUMMARY: V6 SHADOZ data, much improved over v5.2 data [Thompson et al., 2017; Witte et al., 2017, 2018], are recommended for model comparisons, climatology, satellite comparisons. For the "Affected" stations listed in Table (below), data above 40 hPa are not recommended for calculation of trends after the onset of "TCO drop".
!! See tables below for affected stations (red) and unaffected stations (green)!!

SHADOZ Sites: <https://tropo.gsfc.nasa.gov/shadoz>

Map locations: Hilo, HI; Costa Rica (various sites); Paramaribo, Surinam; San Cristobal, Ecuador; Pago Pago, Am. Samoa; Natal, Brazil; Irene, South Africa; Ascension Is.; Nairobi, Kenya; La Reunion Is., France; Suva, Fiji; Hanoi, Vietnam; Kuala Lumpur, Malaysia.





Data Archive & Status in 2020

<https://tropo.gsfc.nasa.gov/shadoz>



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NASA National Aeronautics and Space Administration
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SHADOZ -- Southern Hemisphere Additional Ozoneondes
An Archive of sub/tropical and remote ozoneonde data

HOME | PI CONTACTS | DATA ARCHIVE | NEWSLETTER | PAPERS | LINKS

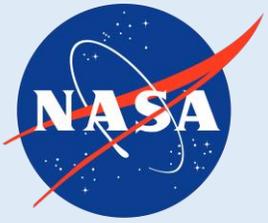
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!! See tables below for affected stations (red) and unaffected stations (green)!!

SHADOZ Sites: <https://tropo.gsfc.nasa.gov/shadoz>

| Station Name | COVID-affected | Jan-20 | Feb-20 | Mar-20 | Apr-20 | May-20 |
|---------------------------|----------------|--------|--------|--------|--------|--------|
| Ascension Island, UK | N/A | | | | | |
| Costa Rica | No | X | X | X | X | X |
| Hanoi, Vietnam | No | X | X | X | X | X |
| Hilo, Hawaii, USA | No | X | X | X | X | X |
| Irene, South Africa * | Yes | | | COVID | COVID | COVID |
| Kuala Lumpur, Malaysia | No | X | X | X | X | X |
| La Reunion Island * | Yes | X | X | COVID | COVID | COVID |
| Nairobi, Kenya * | Yes | X | X | X | X | X |
| Natal, Brazil * | Yes | X | X | COVID | COVID | COVID |
| Pago Pago, American Samoa | No | X | X | X | X | X |
| Paramaribo, Suriname | No | X | X | X | X | X |
| Suva, Fiji * | Yes | X | X | COVID | COVID | X |

X = Stational is operational
* = Five stations have either reduced or interrupted operations due to COVID-19 shutdowns.



Other 2020 Archive Updates



- **New features in progress:**
 - Digital Object Identifier (DOI) for SHADOZ network data.
 - Metadata text files for each station for data users. (eg. instrument/data history)
- Also working with **WMO World Data Centre – Executive Team (WDC-ET)** as a contributing network to improve their database called: **OSCAR (Observing Systems Capability and Analysis Review Tool)**.

```
File Revision Date:
-----
October 11, 2019

Data Set Description:
-----
PI: Anne M. Thompson
Instrument: ECC Ozonesondes
Site: Natal, Brazil (Brazilian Space Agency - INPE, NASA Goddard and Wallops Flight Facility)
Latitude: 5.8S
Longitude: 35.2W
Altitude: 42m amsl

Measurement Quantities: Ozone partial pressure, Ozone mixing ratio, Pressure, Temperature,
Relative humidity, Geopotential height, GPS Altitude, Latitude and Longitude of payload,
and Wind.

Contact Information:
-----
Name:          Dr. Anne M. Thompson
Address:       NASA Goddard Space Flight Center
              8800 Greenbelt Road, Mail Code 614
              Greenbelt, Maryland 20771 U.S.A.
Phone:        1(301)614-5905
FAX:         1(301)614-5903
Email:        anne.m.thompson@nasa.gov

Site Contact:
-----
Name:          Francisco Raimundo da Silva
Address:       Environmental Variables Laboratory
              Brazilian National Institute of Space Research
              Natal, Brazil
Email:        francisco.raimundo@inpe.br
```

Metadata File for Natal @ NDACC

The image shows the header and navigation bar of the OSCAR website. On the left is the WMO logo. The main header contains the text "OSCAR Observing Systems Capability Analysis and Review Tool". To the right of the header are navigation links: "About | News | Glossary | FAQ | Links | Support | Feedback | Login". Below the header is a search bar with a magnifying glass icon and the word "Search". At the bottom left of the page are three buttons: "Home", "Search", and "Critical review".



SHADOZ Newsletter

<https://tropo.gsfc.nasa.gov/shadoz/Newsletter.html>



NASA/GSFC/Atmospheric Chemistry and Dynamics



Newsletter No. 29, 07/2020

SHADOZ Notes

Southern Hemisphere ADDitional OZonesondes

A NASA/Goddard Space Flight Center public archive of tropical and remote ozonesonde profile data

SHADOZ is a NASA project to augment and archive balloon-borne ozonesonde launches and to archive data from tropical and remote operational sites. The project was initiated in 1998 by NASA/Goddard Space Flight Center, the NOAA/Global Monitoring Division, and international co-investigators. There are currently thirteen stations launching ozonesondes in the SHADOZ network. The collective data set provides the first climatology of tropical ozone in the equatorial region, enhances validation studies aimed at improving satellite remote sensing techniques for tropical ozone estimations, and serves as an educational tool to students, especially in participating countries.

SHADOZ Sites: <https://tropo.gsfc.nasa.gov/shadoz>



❖ Ozonesonde Quality Experts Meet Virtually ❖

From 18-20 March 2020, Bryan Johnson (NOAA) remotely hosted an ASOPOS (Assessment of Standard Operating Procedures for Ozonesondes) 2.0 meeting co-chaired by Anne Thompson and Herman Smit. The goal of ASOPOS is the preparation of a new WMO Report on ozonesonde principles and best practices. Attendees (at right) presented updates of Standard Operating Procedures (SOPs) and lab tests. Manufacturers from EnSci, Science Pump and Vaisala participated. R. Stauffer presented total column ozone dropoffs from some SHADOZ stations from *Stauffer et al.* (2020; page 2) and D. Kollonige showed responses from recent SHADOZ station surveys on ozonesonde preparation. Since March, the ASOPOS team has met monthly. The Draft Report will be peer-reviewed July-Sept., then sent to WMO.

ASOPOS 2.0 Meeting Attendees: David Tarasick & Jonathan Davies (ECCC), Debra Kollonige (SHADOZ Archiver; NASA), Bryan Johnson & Patrick Cullis (SHADOZ Co-I; NOAA), Anne Thompson (SHADOZ PI; NASA), Peter VonDerGathen (AWI Germany), Holger Vömel (SHADOZ Costa Rica; NCAR), René Stübi, (SHADOZ Nairobi; Meteoswiss), Ankie Pijters & Marc Allart (SHADOZ Paramaribo; KNMI), Herman Smit (Jülich), Ryan Stauffer (SHADOZ; NASA), Roeland Van Malderen (RMI), Gary Morris (St. Edwards Univ.), Herman Smit (FZ-Juelich).

❖ COVID-19 Impacts on Stations ❖

| Station Name | COVID-affected | Jan-20 | Feb-20 | Mar-20 | Apr-20 | May-20 |
|---------------------------|----------------|--------|--------|--------|--------|--------|
| Ascension Island, UK | N/A | | | | | |
| Costa Rica | No | X | X | X | X | X |
| Hanoi, Vietnam | No | X | X | X | X | X |
| Hilo, Hawaii, USA | No | X | X | X | X | X |
| Irene, South Africa * | Yes | | | COVID | COVID | COVID |
| Kuala Lumpur, Malaysia | No | X | X | X | X | X |
| La Reunion Island * | Yes | X | X | COVID | COVID | COVID |
| Nairobi, Kenya * | Yes | X | X | X | X | X |
| Natal, Brazil * | Yes | X | X | COVID | COVID | COVID |
| Pago Pago, American Samoa | No | X | X | X | X | X |
| Paramaribo, Suriname | No | X | X | X | X | X |
| Suva, Fiji * | Yes | X | X | COVID | COVID | X |

* = Station is operational
 * = Few stations have either reduced or interrupted operations due to COVID-19 shutdowns.

With the unprecedented events surrounding the COVID-19 outbreak, all of the SHADOZ stations and their staff went to great lengths to maintain their ozonesonde launch schedules after March. The table (left) shows the list of stations impacted with either reduced or interrupted operations due to COVID-19 shutdowns globally. We heard several success stories in keeping launches going in some capacity where possible. **Great effort by everyone!**

SHADOZ Newsletter No. 29

❖ Upcoming Relevant Meetings ❖

SHADOZ will be represented at the following:

17 July 2020:
NOAA Global Monitoring Laboratory
Virtual Global Monitoring Annual Conference (eGMAC)

4-6 Nov. 2020:
NDACC Steering Committee Meeting

10-14 Jan. 2021:
American Meteorological Society Meeting

Attention Data Users:

- Questions about SHADOZ should be directed to PI, Anne Thompson. SHADOZ data sets are products of evolving research by the site Co-Investigators (Co-Is) and ongoing community collaboration.
- The SHADOZ homepage gives technical and contact information for each station and their Co-Is responsible for the original data processing. Co-Is should be consulted for details of their methods & appropriate references to their work.
- Questions about the final data and any news updates should be directed to the Archiver: Debra Kollonige.

➔ SHADOZ Network Science Team ◀



Dr. Anne M. Thompson
Principal Investigator (PI)
anne.m.thompson@nasa.gov



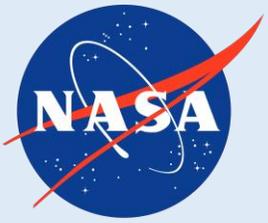
Dr. Ryan M. Stauffer
SHADOZ Research Assoc.
ryan.m.stauffer@nasa.gov



Dr. Debra E. Kollonige
Data Archiver/Webmaster
debra.e.kollonige@nasa.gov

| SHADOZ Site | Principal Investigator (PI), Station Chiefs and Operators |
|------------------------|--|
| Ascension Is., U.K. | Anne Thompson (PI: anne.m.thompson@nasa.gov) & Ryan Stauffer (NASA/GSFC) Peter Crane & Patrick Benjamin, Leroy Hudson, Iona Yon (US Air Force AFSPC E-ROS/Wolf Creek) |
| San Pedro, Costa Rica | Henry Sellink (PI: henry.b.sellink@nasa.gov ; NASA/USRA), Holger Vömel (NCAR), Jorge Andres Diaz & Ernesto Corrales (UCR) |
| Hanoi, Vietnam | Shin-Ya Ogino (PI: ogino-sy@jamstec.go.jp ; JAMSTEC), Nguyen Thi Hoang Anh, Tran Thu Huang & Lai Thanh Nga (AMO) |
| Hilo, HI USA | Bryan Johnson (PI: bryan.johnson@nasa.gov ; NOAA/GMD), David Nardini & Darryl Kuniyuki (NOAA/MLO) |
| Irene, South Africa | Gert J. R. Coetzee (PI: gerrie.coetzee@weathersa.co.za ; SAWS), Tshidi Machinini (SAWS) |
| Kuala Lumpur, Malaysia | Mohan Kumar Sammathuria (PI: mohan@met.gov.my), Mohd Firdaus Bin Jayaha, Nur Aleesha Abdullah & Ab Rahman Buang (MMD) |
| La Reunion Is., France | Françoise Posny (PI: francoise.posny@univ-reunion.fr), Jean-Marc Metzger (U. Reunion) |
| Nairobi, Kenya | Christian Félix (PI: christian.felix@meteoswiss.ch), René Stübi & Gonzague Romanens (Meteoswiss), Kennedy Thiongo (KMD) |
| Natal, Brazil | Francisco R. da Silva, Tercio L. B. Penha (INPE) |
| Paramaribo, Suriname | Ankie Pijters (PI: ankie.pijters@knmi.nl) & Marc Allart (KNMI), Sukarni Mitro & George Paiman (MDS) |
| Pago Pago, Am. Samoa | Bryan Johnson (PI: NOAA/GMD), LTJG Diane M. Perry (NOAA/ASO) |
| San Cristóbal, Ecuador | Bryan Johnson (PI: NOAA/GMD), INAMHI |
| Suva, Fiji | Bryan Johnson (PI: NOAA/GMD), Matakite Maata, Francis Mani & Miriama Vuyiasawa (USP) |

What about SHADOZ data quality?

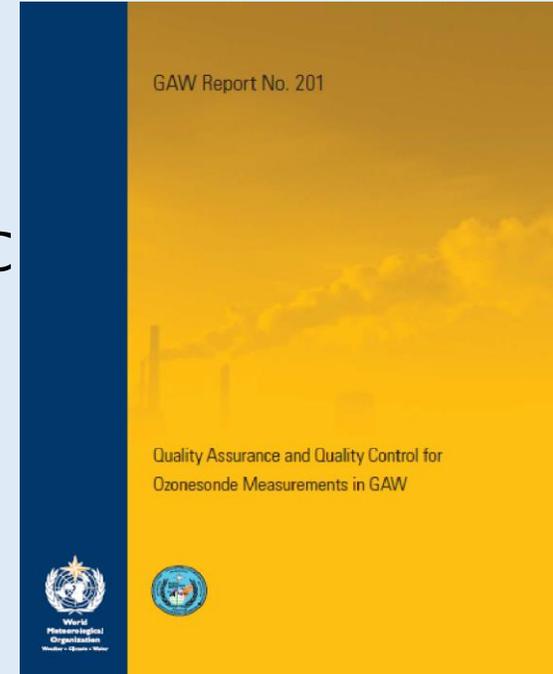


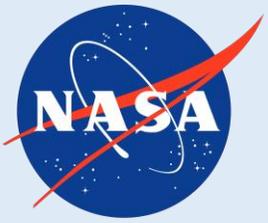
Data Quality Assurance: ASOPOS Activity

Assessment of Standard Operating Procedures for OzoneSondes



- **Major Initiative in 2020:** Update WMO/GAW OzoneSonde Guidelines Report 201, “OzoneSonde Bible” for preparation, calibration, & operation.
- **H. Smit & A. Thompson** are co-leads for WMO ASOPOS 2.0 Report on ECC ozoneSonde principles, best practices, and data quality.
- **March 2020 Virtual ASOPOS Meeting:**
 - Updates of SOPs and lab tests.
 - Manufacturers from EnSci, Science Pump and Vaisala participated.
 - R. Stauffer presented total column ozone dropoffs from some SHADOZ stations from GRL paper.
 - D. Kollonige showed responses from recent SHADOZ station surveys on ozoneSonde preparation.
- **Draft ASOPOS 2.0 Report will be peer-reviewed July-Sept. 2020.**





Data Quality Assurance: ASOPOS Activity

Global Ozonesonde Station Survey



- Motivation for **Initial SHADOZ Survey**: ~50 % of SHADOZ network stations are “Affected” by TCO drop-off.
- **By December 2019**: Sent 1st survey to SHADOZ stations and heard from 10 of 12 active SHADOZ stations.
- **Jan 2020**: We started developing a **Global station survey** with additional questions from suggestions from the ASOPOS team.
- **April 2020**: Google survey ready to send.
- **June 2020**: 25 Responses to Global Survey including European Stations.

Global Ozonesonde Station Survey

Goal: Obtain information on standard operating procedures for stations

* Required

Email address *

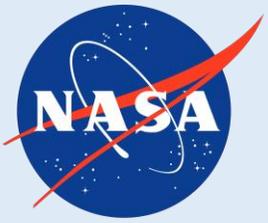
Your email

What is your station name or location? *

Your answer

1) What type of ECC ozonesonde do you currently use at your site? *

Goal: Link common combinations of equipment & procedures to dropoff affected sites.

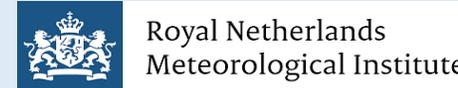


Summary & Thank You!

<https://tropo.gsfc.nasa.gov/shadoz>



- SHADOZ, now with >8700 profiles, fills an otherwise huge gap in tropical ozonesonde data availability.
- New SHADOZ publications in 2020!
- Many updates for 2020:
 - SHADOZ Archive additions
 - WMO ASOPOS 2.0 Report
 - Global Ozonesonde Station Survey with SHADOZ participation to help with data quality assurance.



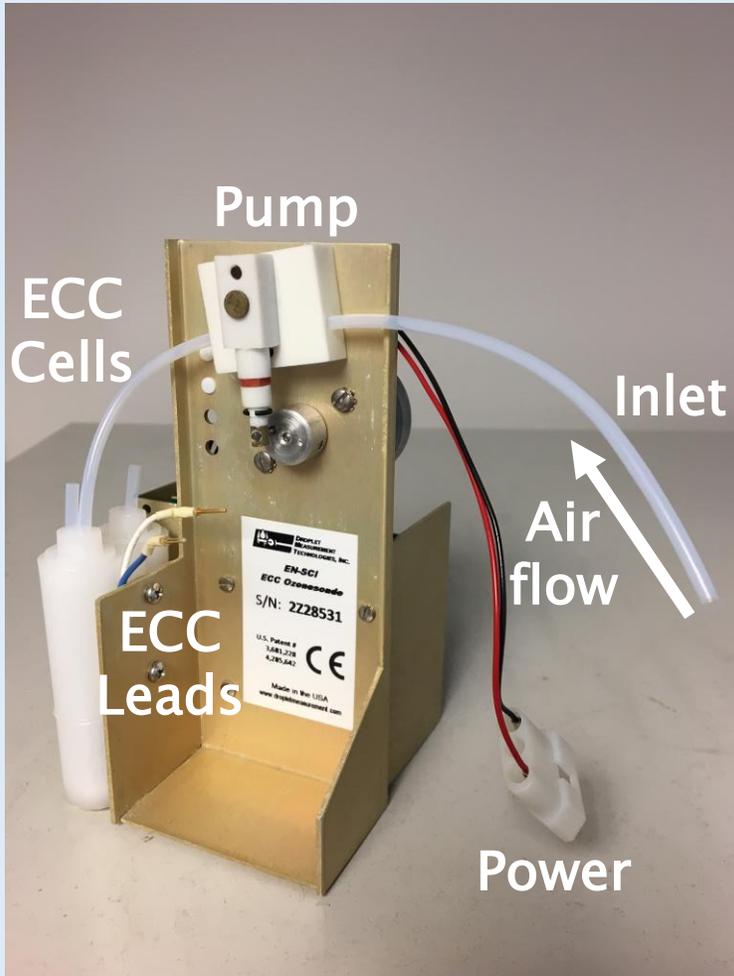
Major Partners: NOAA/GMD, NASA Wallops

NASA HQ: M. Kurylo (1998-2008), K. Jucks (2008->) and J. Kaye

Backup Slides

The ECC Ozonesonde

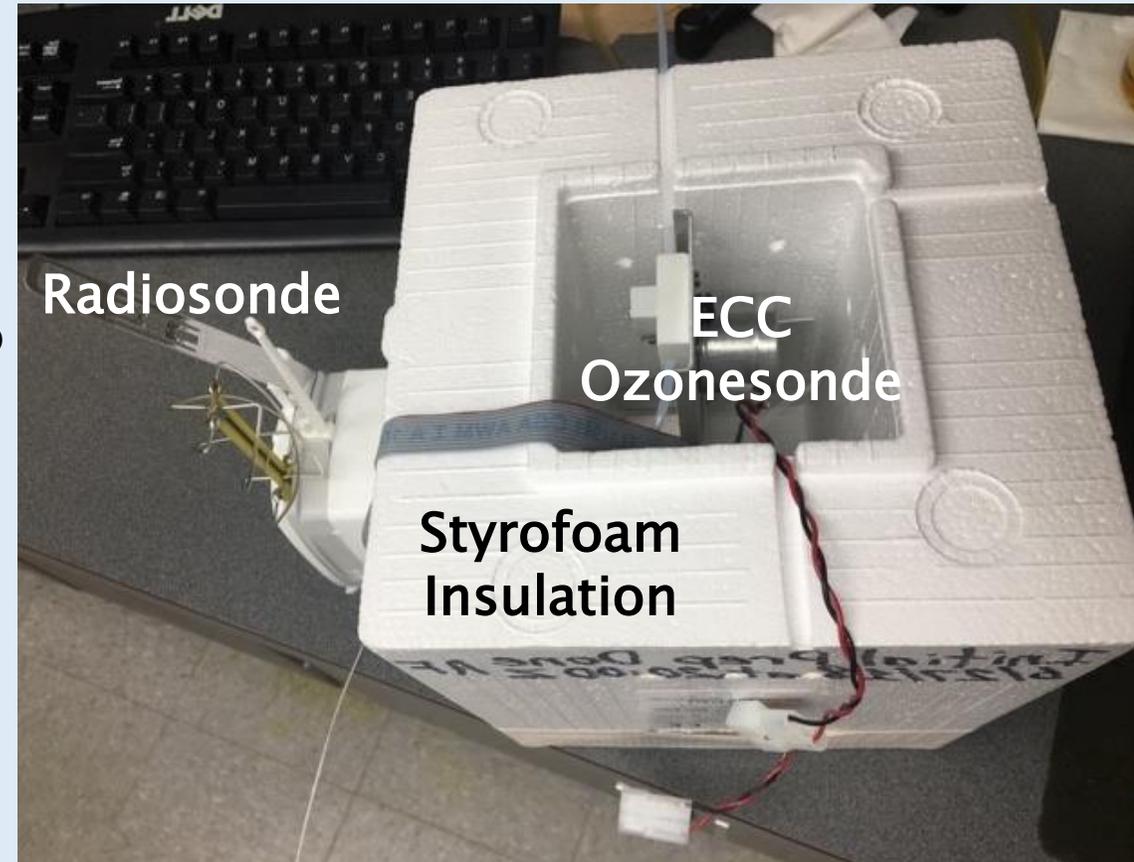
The Electrochemical Concentration Cell (ECC) Ozonesonde technique is over 50 years old
“If it ain’t broke, don’t fix it!”



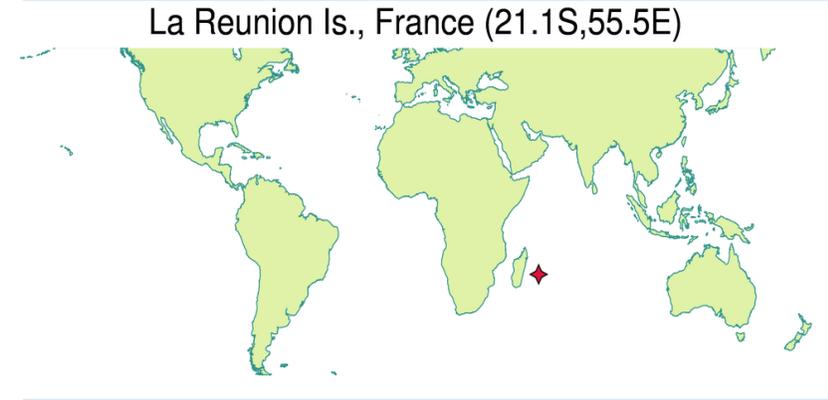
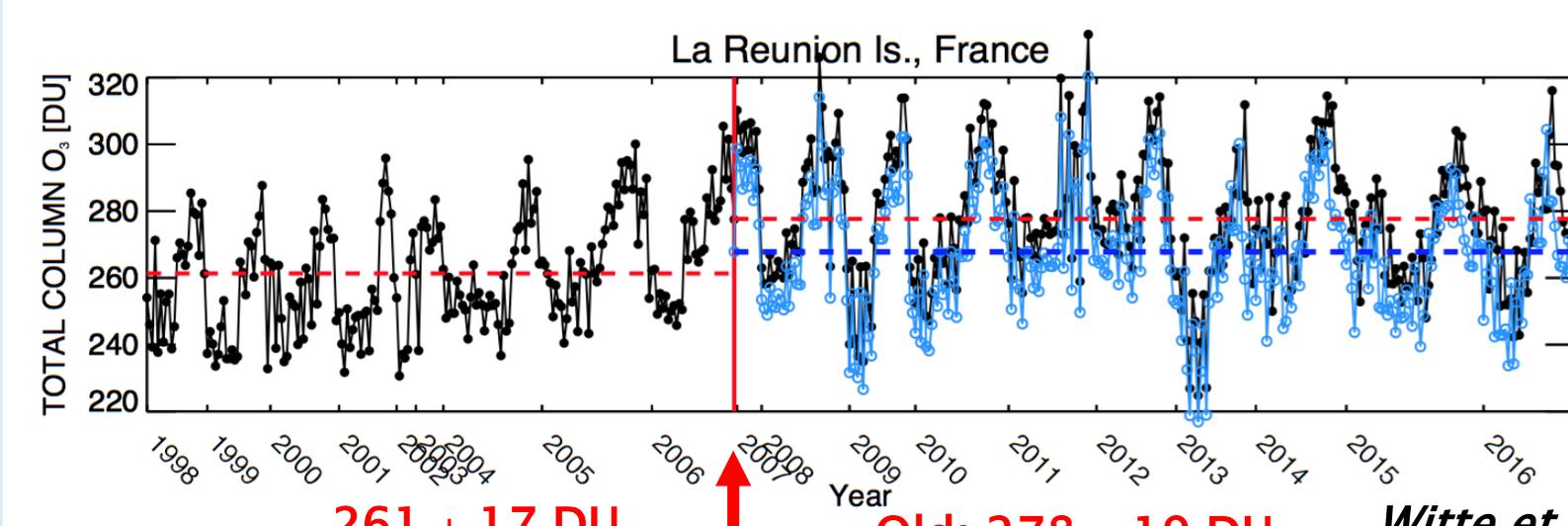
←The ECC Cells are filled with a KI solution that reacts with O_3 and generates an electrical current

One O_3 molecule = Two electrons generated

The ECC is packaged in styrofoam, attached to a radiosonde, and sent up on a weather balloon with O_3 , p, T, RH, and GPS data transmitted to a ground station→



Reprocessing the Data for Better Accuracy



261 ± 17 DU

Old: 278 ± 19 DU

New: 268 ± 18 DU

Witte et al. (2017); Thompson et al. (2017)

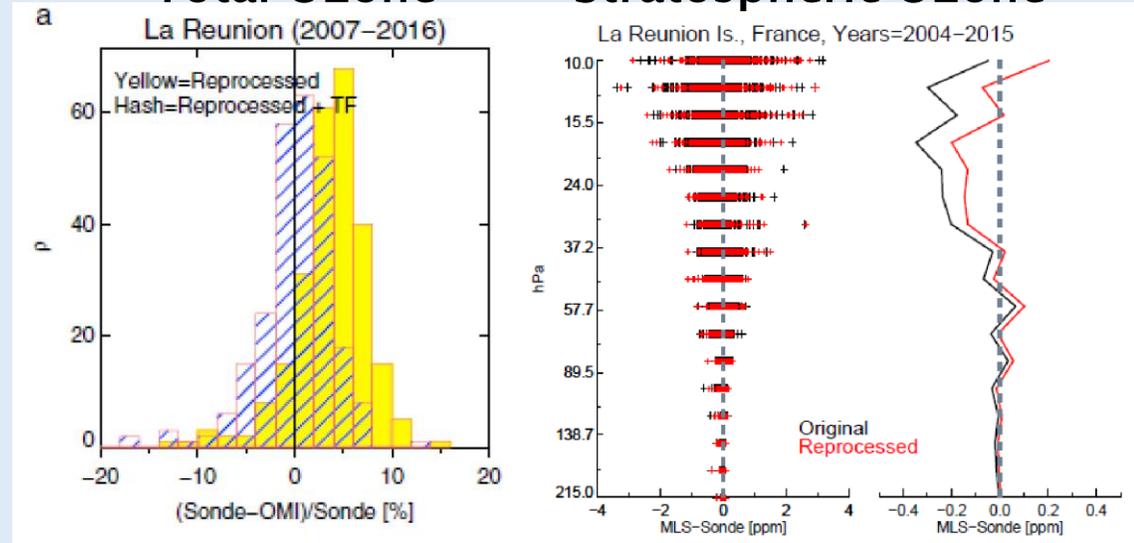
Total Ozone

Stratospheric Ozone

Example from Réunion Island, which switched to a non-standard KI ozonesonde sensing solution in **2007**

Knowledge from lab and field tests allow us to reprocess and correct biased data

Top: Reprocessing lowers total ozone, now more in line with previous record. **Bottom:** Comparisons with satellite data are much improved. 5% uncertainty goal achieved!



2020 Global Ozonesonde Stations Survey Responses

Global survey can be found here: <https://forms.gle/KYeL85eYjkknvuY29>

| What is your station name or location? | Dropoff Affected station? | 1) What type of ECC ozonesonde do you currently use at your site? | 2) What type of radiosonde is currently used at your site? |
|---|---------------------------|---|--|
| Sodankylä | No | En-Sci | RS-92 |
| Hohenpeißenberg | N/A | Other (what kind?) | RS-41 |
| ESTACION DE RADIOSONDEOS DE BARAJAS - Ma | No | Science Pump Corp. | RS-41 |
| Lauder, New Zealand | No | En-Sci | iMet, RS-41 |
| Irene, South Africa | No | Science Pump Corp. | RS-41 |
| Praha (ozonosonde station at the Czech Republic) | No | Science Pump Corp. | RS-41 |
| Izaña, Tenerife, Spain | No | Science Pump Corp. | RS-41 |
| Broadmeadows | No | Science Pump Corp. | RS-41 |
| Macquarie Island | No | Science Pump Corp. | RS-41 |
| Davis | No | Science Pump Corp. | RS-41 |
| Legionowo, Poland | No | Science Pump Corp. | RS-41 |
| Ittoqqortoormiit (Scoresbysund) | No | En-Sci | RS-41 |
| 03005 Lerwick – Shetland Isles 60° 07' 58" N, 01° 1 | No | Science Pump Corp. | RS-41 |
| NASA Wallops Flight Facility | No | Science Pump Corp. | LMS |
| Boulder, CO | No | En-Sci | iMet |
| San Jose, Costa Rica | Yes | En-Sci | iMet |
| Uccle | No | En-Sci | RS-41 |
| La Reunion | No | En-Sci | Modem10 |
| Fiji | Yes | En-Sci | iMet |
| Natal, Brazil | Yes | Science Pump Corp. | LMS |
| Paramaribo, Suriname | No | Science Pump Corp. | RS-41 |
| Ascension Island | Yes | En-Sci | iMet |
| Nairobi | Yes | En-Sci | RS-92 |
| Boulder | No | En-Sci | iMet |
| Hilo, HI | Yes | En-Sci | iMet |
| Samoa | Yes | En-Sci | iMet |
| Payerne | No | En-Sci | RS-41 |
| Houston | No | En-Sci | iMet |
| San Antonio | No | En-Sci | iMet |
| El Paso | No | En-Sci | iMet |
| Idabel | Yes | En-Sci | iMet |
| Austin | No | En-Sci | iMet |
| Tateno(Tsukuba) (Japan) | No | En-Sci | Other |
| Syowa (Japan) (Antarctica) | No | En-Sci | Other |

**10 responses
from European
Stations.**

Affected Stations in Red